Dealing with

Greenhouse Gas Inventories

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Agenda

- The Greenhouse Gases
- Evolution of Inventory Requirements
- GHG Protocol
- Voluntary vs. Regulatory
- Emission Calculations
- Sample Footprint Calcs
- Documentation Requirements

- Mandatory Reporting for EPA
- Scope 3 Product Chain

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The Greenhouse Gases

Compound	Symbol	Common Sources
Carbon dioxide	CO_2	Energy, processes
Methane	CH_4	Wastes, combustion
Nitrous oxide	N_2O	Fertilizers, combustion
Hydrofluorocarbons	HFCs	Refrigerants
Perfluorocarbons	PFCs	Solvents
Sulfur hexafluoride	SF_6	Transformers

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Global Warming Potential (GWP)

- Multipliers represent 100-year equivalent radiative forcing
- Changes with each IPCC assessment (EPA rule uses 3rd)

Greenhouse Gas	Global Warming Potential (CO_2-eq)
Carbon Dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous Oxide (N_2O)	310
HFCs	120-12,000
PFCs	5,700-11,900
Sulfur Hexafluoride (SF_6)	23,900

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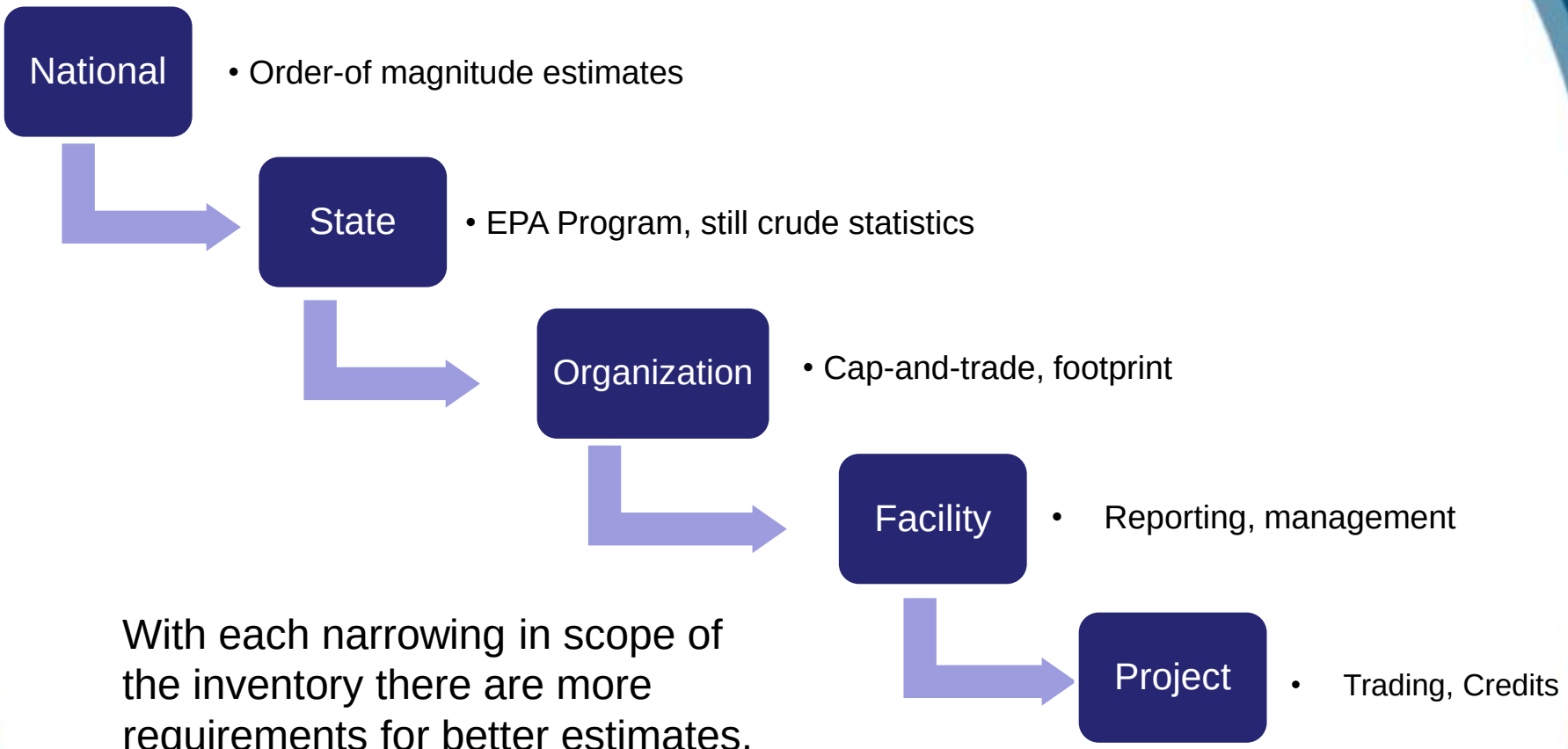
Evolution of Inventory Requirements



With each narrowing in scope of the inventory there are more requirements for better estimates, and verification

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Evolution of Inventory Requirements

- Voluntary Commitments

- Mandatory Requirements
  - First-ever EPA reporting requirement

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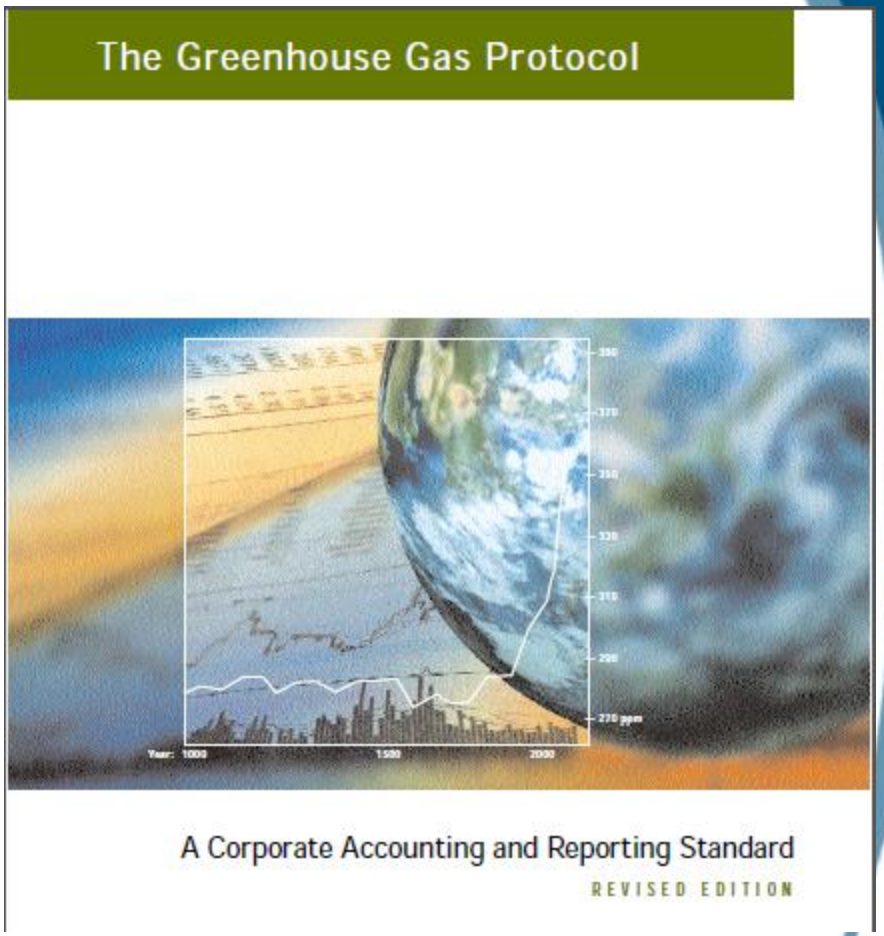
GHG Protocol

- Developed by the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD)
- First comprehensive protocol
- Became the international standard
- Most programs today use some variation



www.ghgprotocol.org

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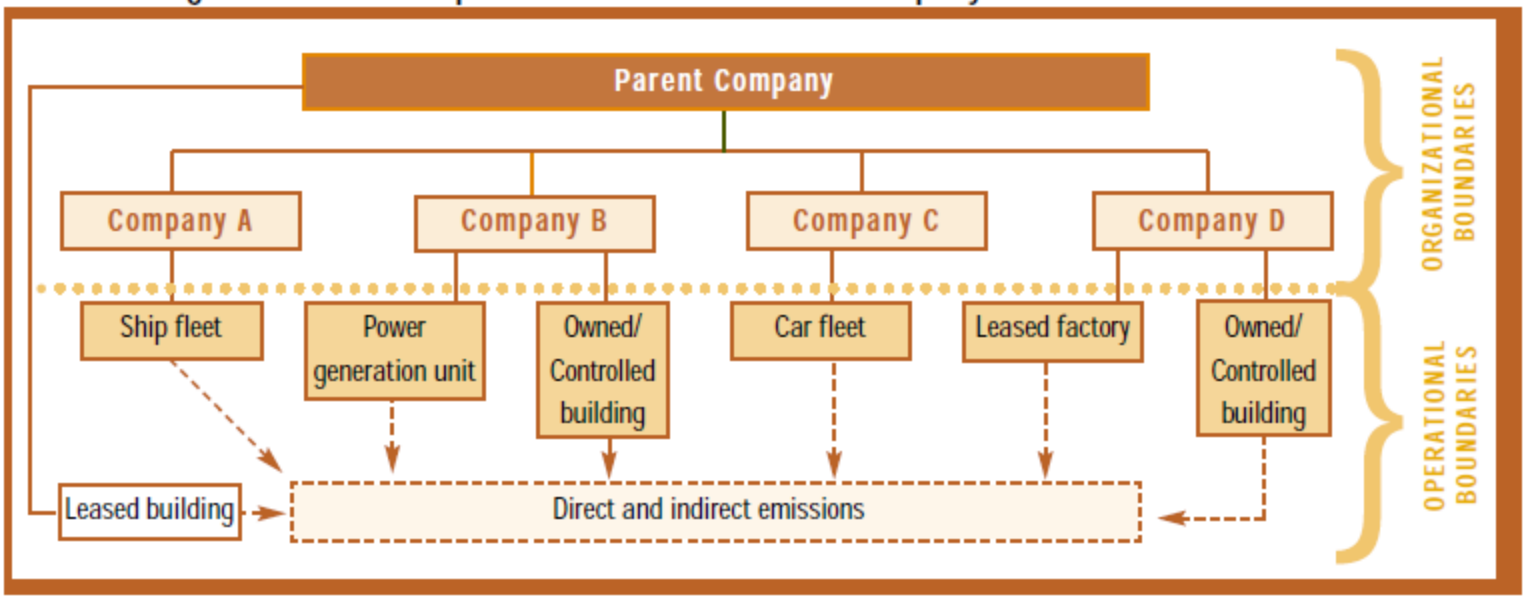
GHG Protocol Basics

- Method to Define Boundaries
  - Financial Control Model
  - Operational Control Model

FIGURE 2. Organizational and operational boundaries of a company



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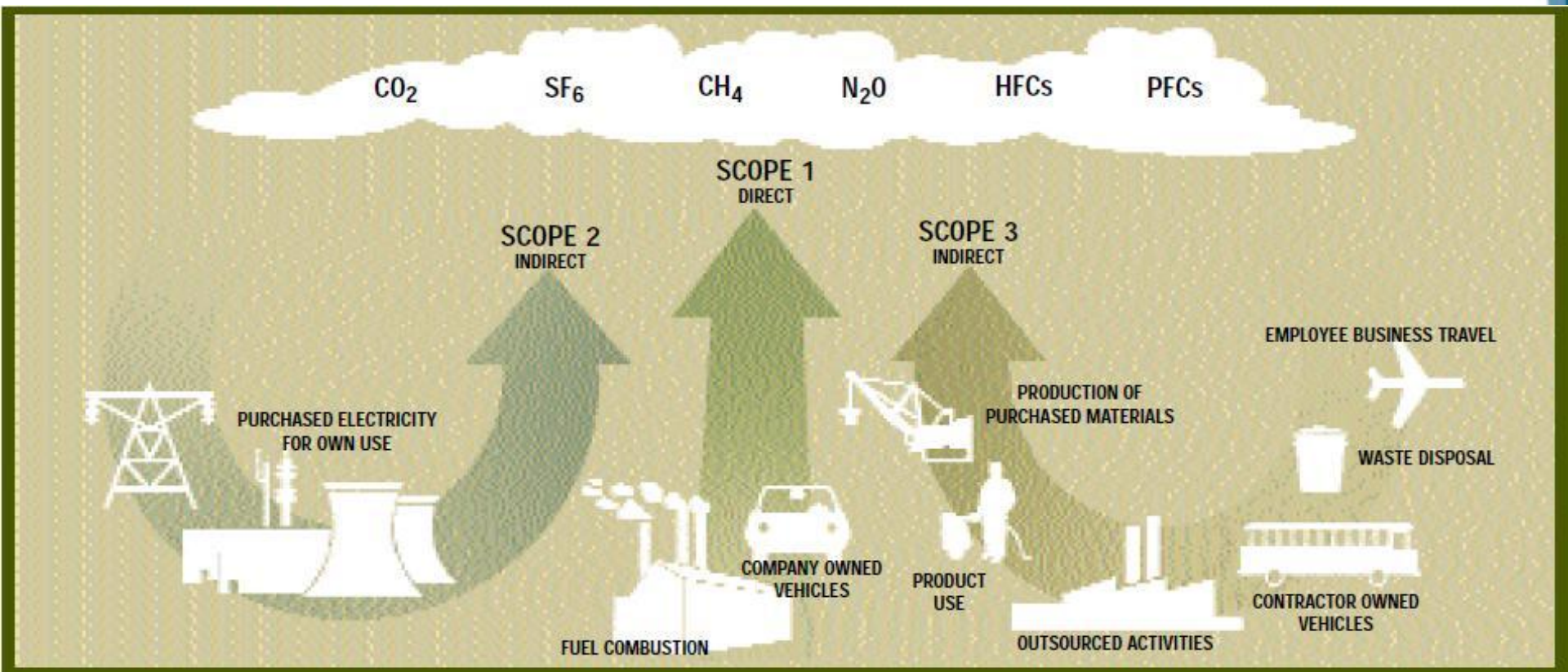
GHG Protocol Basics

- Concept of ‘Scopes’ to track ownership
- Set up for Verification



Defining the Scopes

- Scope 1 = My emissions from burning fuels or operating an emitting process
- Scope 2 = Emissions created by the electricity provider in order to satisfy my usage
- Scope 3 = Emissions created by others that result because of my operation

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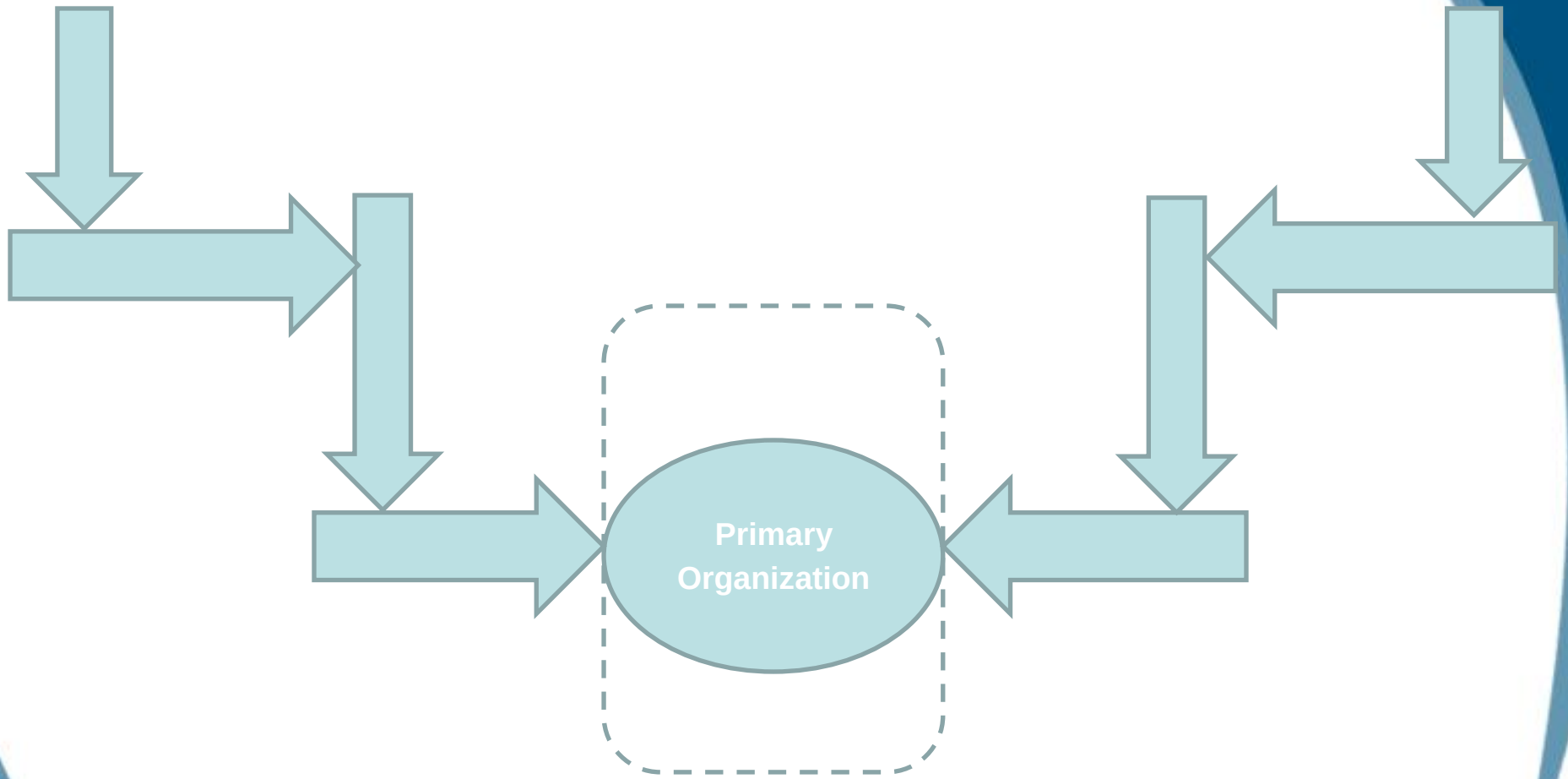
Boundary Setting



- The greatest challenge lies in setting the boundaries
- Regulations will define boundaries for you

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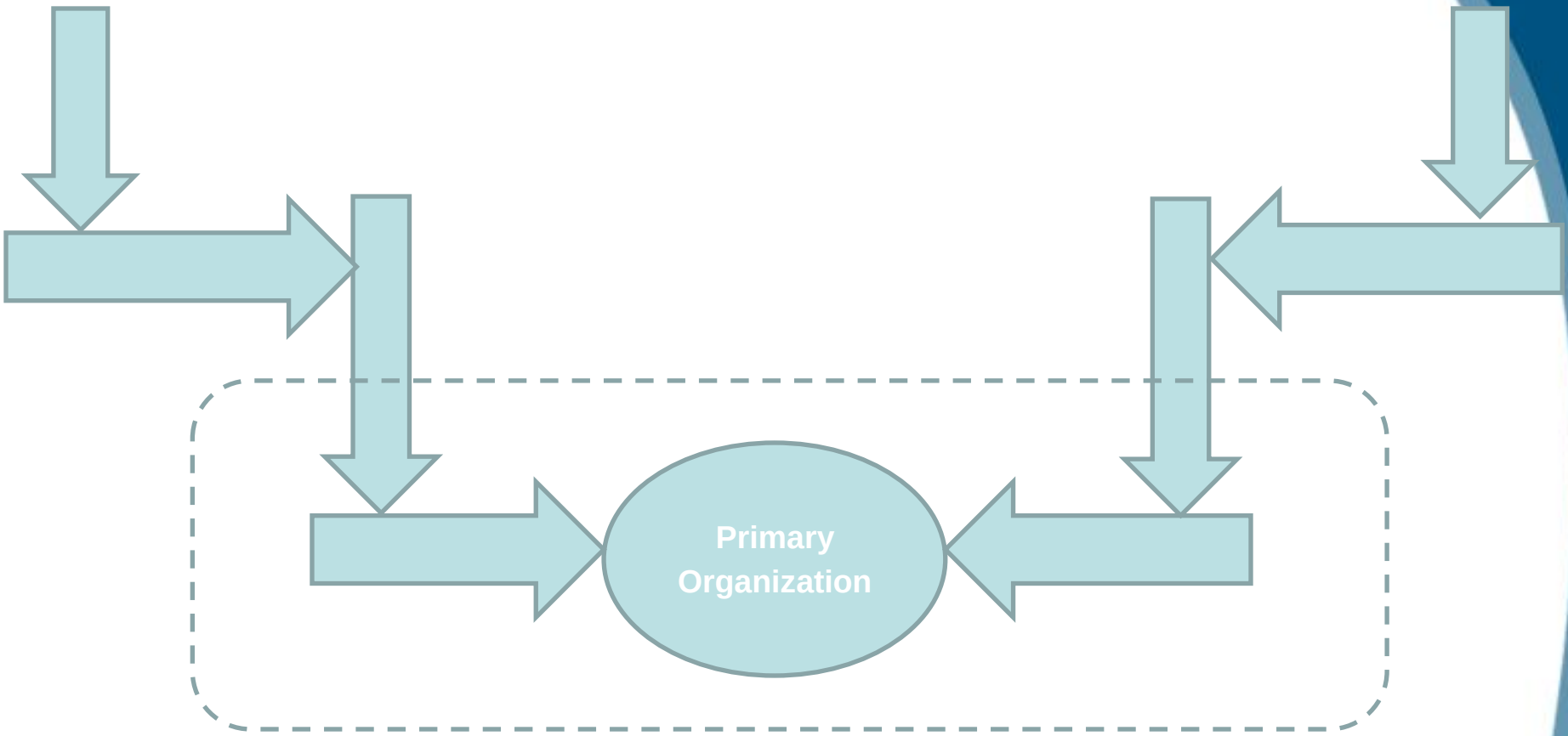
Boundary Setting



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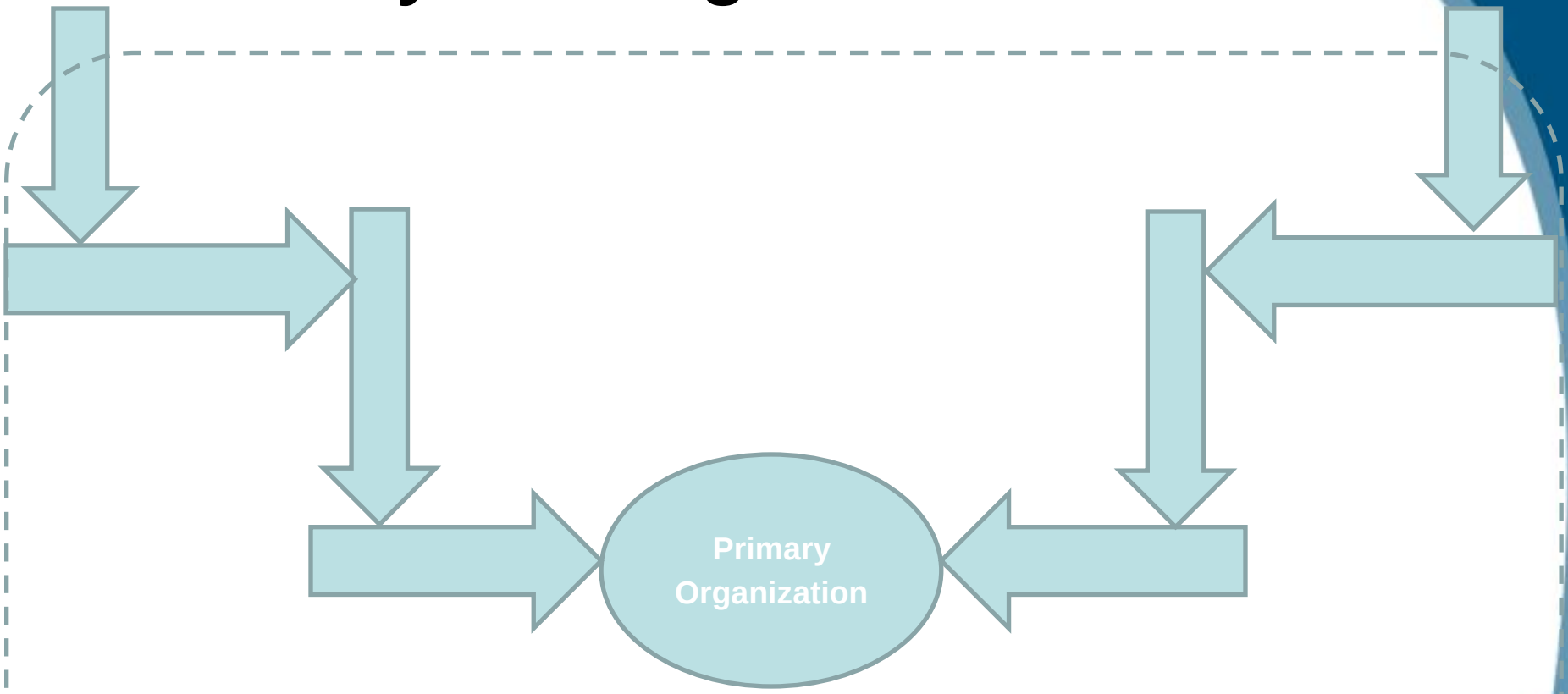
Boundary Setting



- The greatest challenge lies in setting the boundaries
- Regulations will define boundaries for you

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Tips for Boundary Setting

- Look at what is material
  - Don’t chase gnats, look for the elephants
- Look at the quality of the estimate
  - When the uncertainty in the numbers is approaching the size of the activity’s contribution, think again
- Apply the common-sense test – when dealing with a voluntary program

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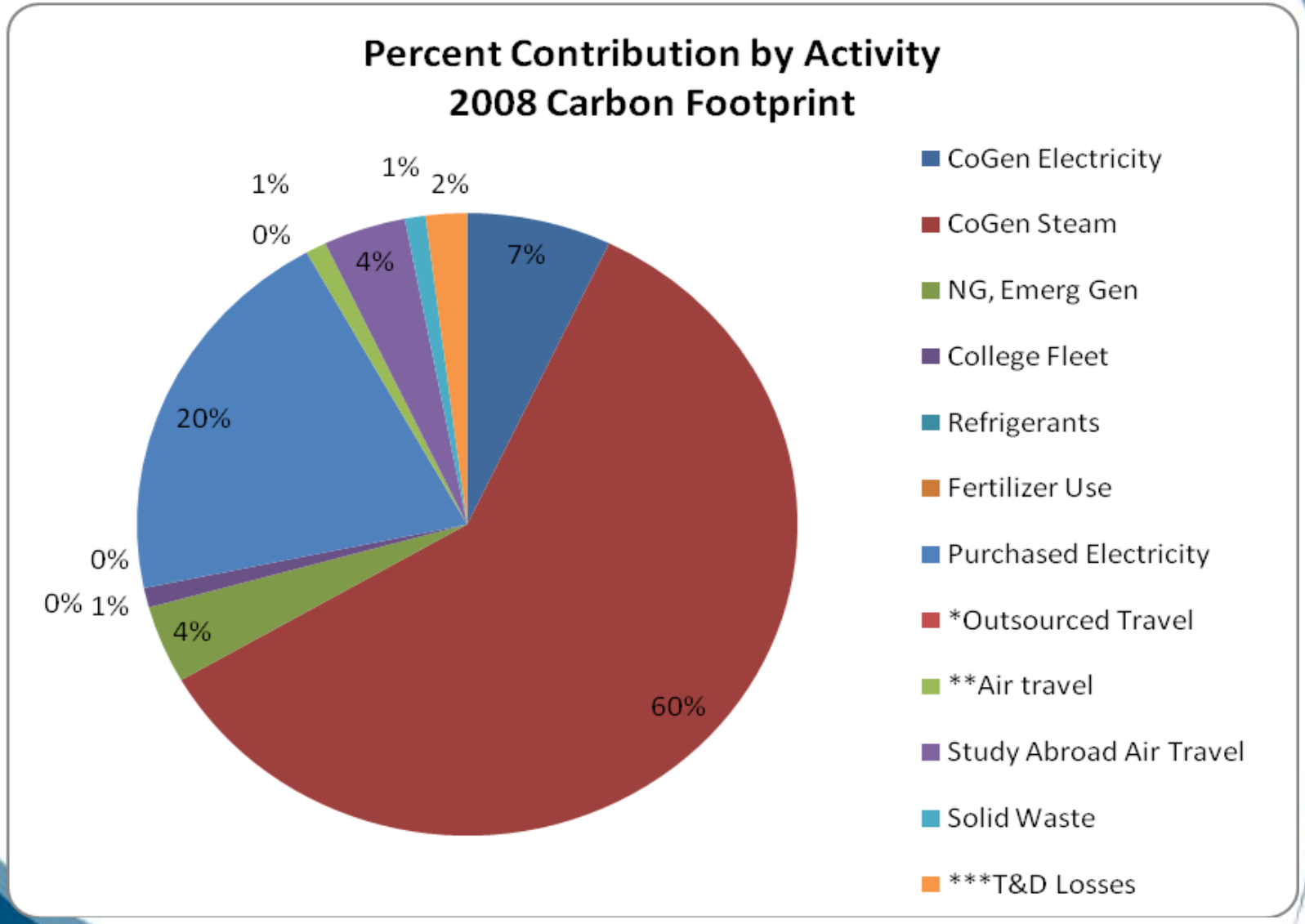
Voluntary vs. Regulatory

- Voluntary reporting
  - Tends to focus on broader '*carbon footprint*'
  - Often includes emissions from all Scopes
  - Less rigorous, but increasing verification needs
  - Often a voluntary commitment to reduce
  - Corporations, Higher Education, Cities
- Regulatory reporting
  - Focus on direct emissions (Scope 1, Scope 2)
  - Prescribed methods

A Sample Carbon Footprint



Regulatory Developments

- Mandatory Reporting Program – 10/30/09
- EPA Endangerment Finding – 12/7/09
- Regulation of GHG from motor vehicles – 5/7/10
  - Means CO_2 is a 'regulated pollutant'
- Stationary sources regulated under New Source Review – Prevention of Significant Deterioration (PSD)
  - Tailoring Rule

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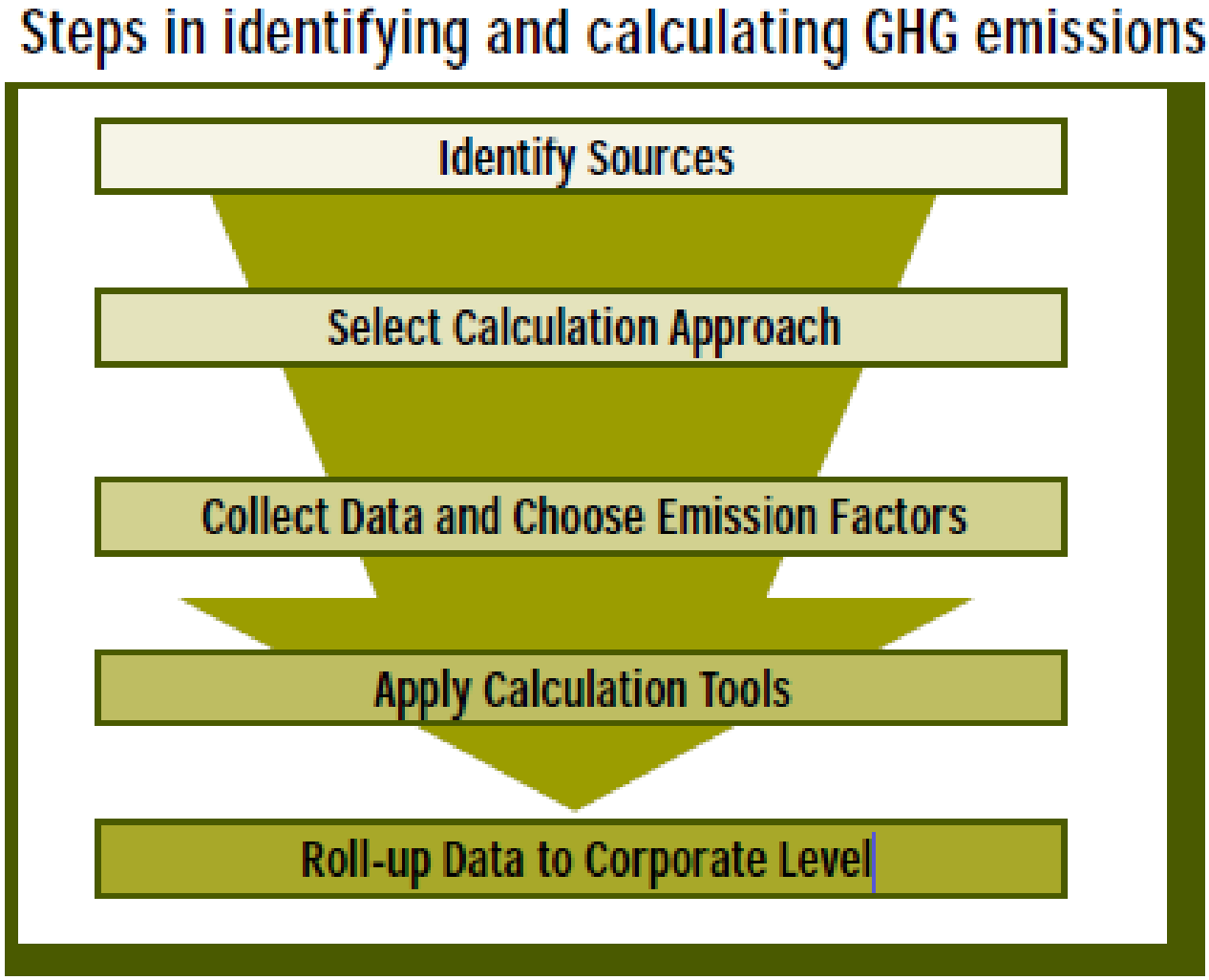
The Standard Approach:



From WRI

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Basic Emission Calculations

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Fuel Combustion

- Based upon mass balance:
  - The carbon content of the fuel:
  - The oxidation rate for carbon in the fuel:

Default Carbon Content Values (Based on GCV or HHV)[a,d]			
	(kg C/GJ)		
Fuel Type	Range	Typical	IPCC Default[e]
Coal-based fuels			
Anthracite coal	25-30	27	25.5
Bituminous coal	22-26	24	24.5
Sub-bituminous coal	23-28	25	24.9
Lignite coal	23-29	26	26.2
Coal coke	26-38	29	
Patent fuel	23-30	25	24.5
BKB	23-30	25	24.5
Natural gas-based fuels			
Natural gas	13-16	14	
Natural gas (dry)	13-16	14	13.8

Default Oxidation Factor Values (Based on GCV or HHV)			
Fuel/Technology Type	Range	Typical	IPCC Default
Coal-based fuels	91-100%	99%	98%
Newer boilers		99%	
Older boilers		98%	
Stoker boilers		98%	
Natural gas-based fuels	99-100%	100%	99.5%
Petroleum-based fuels	97.5-100%	100%	99%
Gasoline internal combustion engines		100%	
Diesel internal combustion engines		99%	

= Fuel Used * fuel carbon content * oxidation % * 44/12 = CO_2

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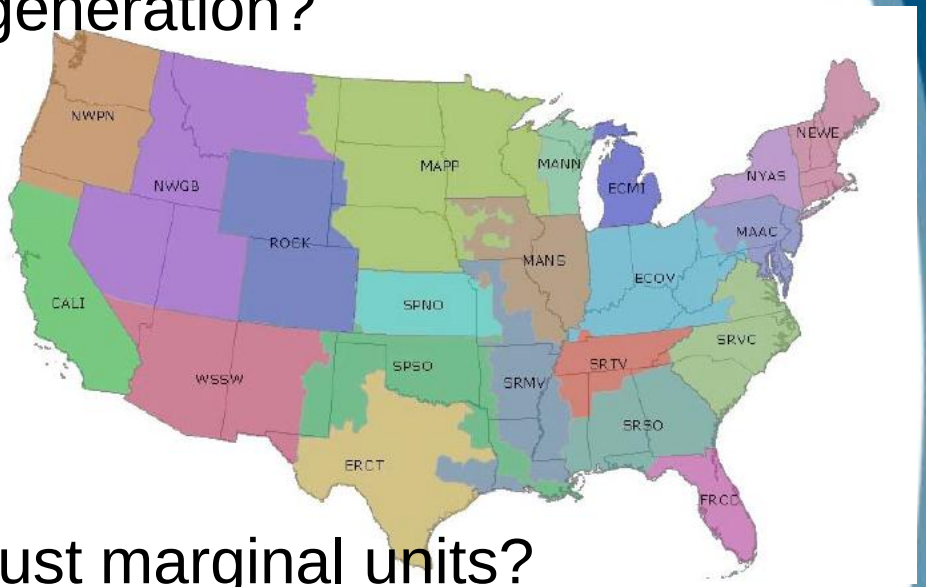
Electricity

- How to represent the mix of generation?
  - National Average
  - State-level Average
  - NERC Region/Subregion
  - Serving Utility's Mix
  - Individual power plant



- Average of all generation or just marginal units?

- Transmission and distribution losses

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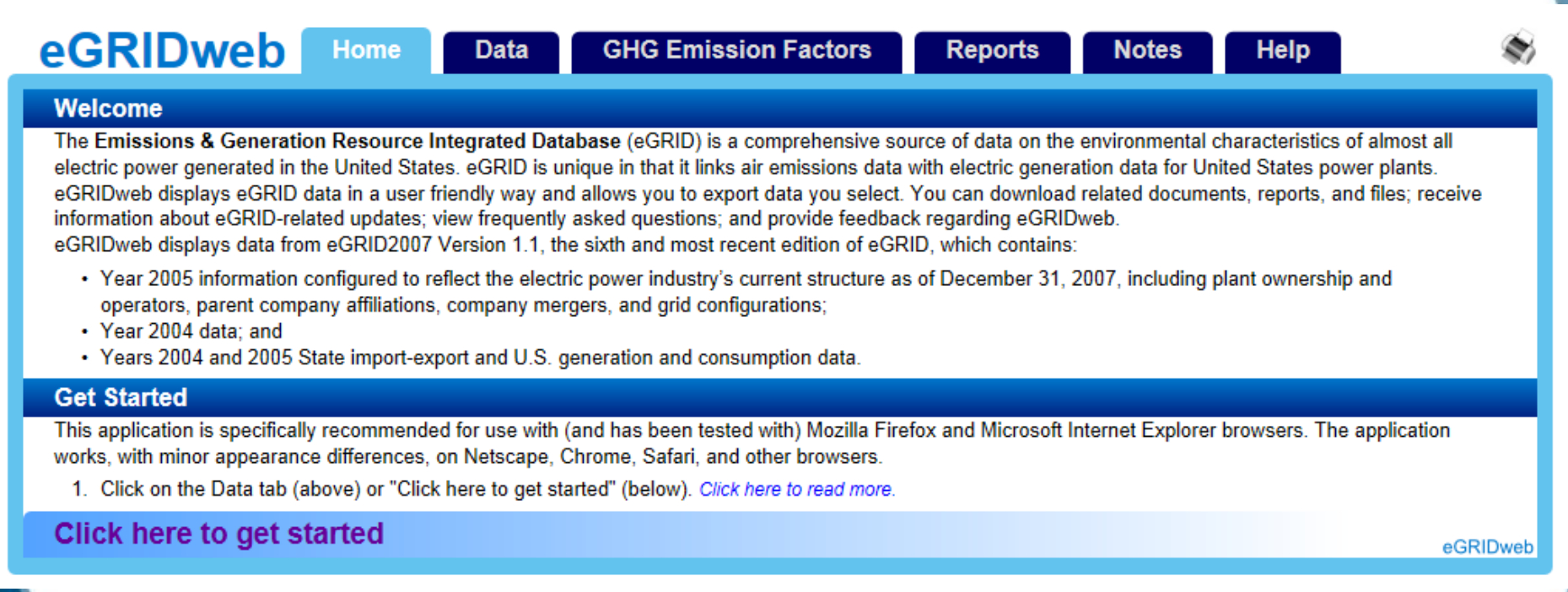
eGRID



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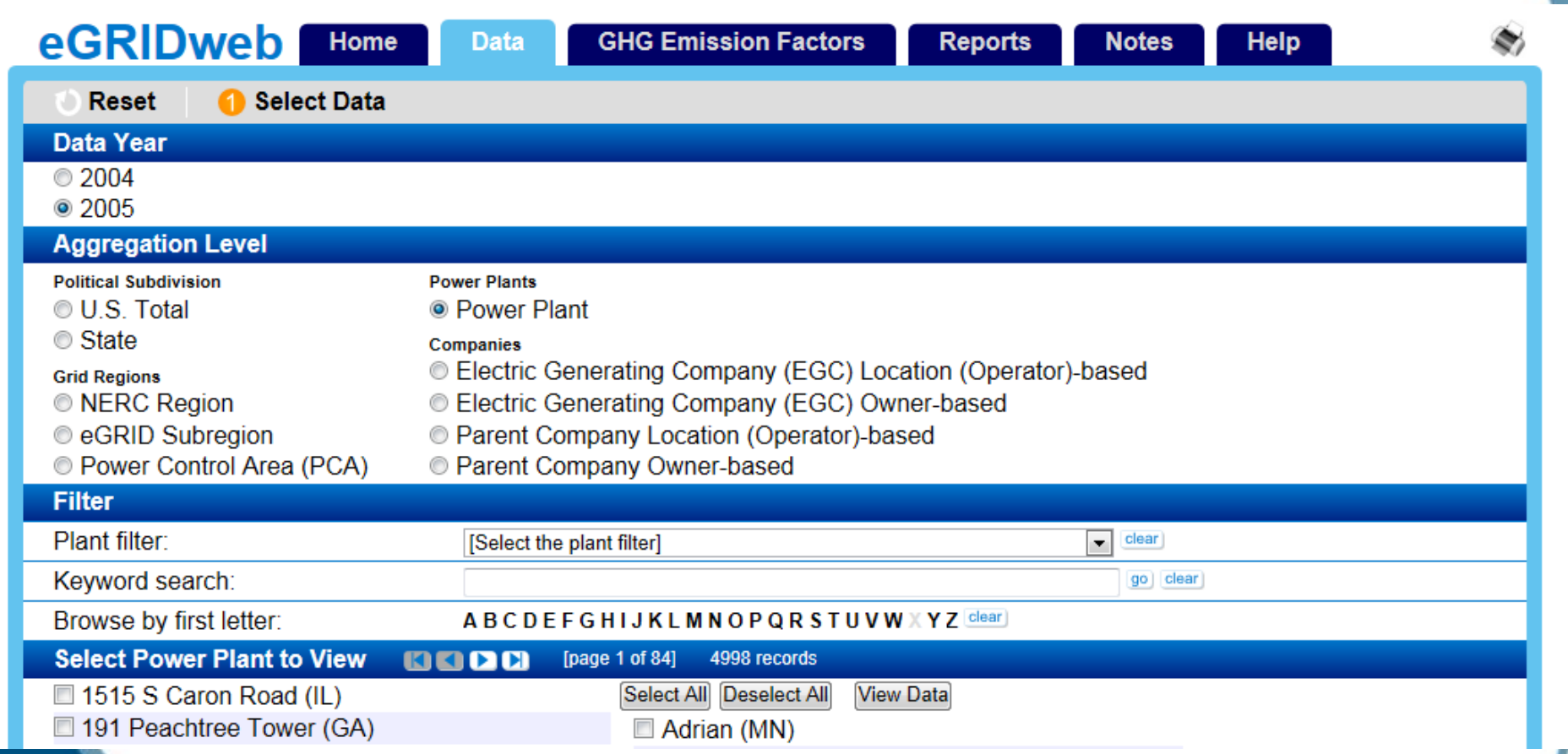

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eGRID

eGRIDweb | Home | Data | GHG Emission Factors | Reports | Notes | Help

eGRID2007 Version 1.1 Year 2005 GHG Annual Output Emission Rates

Annual output emission rates for greenhouse gases (GHGs) can be used as default factors for estimating GHG emissions from electricity use when developing a carbon footprint or emission inventory Annual non-baseload output emission rates should not be used for those purposes, but can be used to estimate GHG emissions reductions from reductions in electricity use.

eGRID subregion acronym	eGRID subregion name	Annual output emission rates			Annual non-baseload output emission rates		
		Carbon dioxide (CO2) (lb/MWh)	Methane (CH4) (lb/GWh)	Nitrous oxide (N2O) (lb/GWh)	Carbon dioxide (CO2) (lb/MWh)	Methane (CH4) (lb/GWh)	Nitrous oxide (N2O) (lb/GWh)
AKGD	ASCC Alaska Grid	1,232.36	25.60	6.51	1,473.43	36.41	8.24
AKMS	ASCC Miscellaneous	498.86	20.75	4.08	1,457.11	60.47	11.87
AZNM	WECC Southwest	1,311.05	17.45	17.94	1,201.44	20.80	8.50
CAMX	WECC California	724.12	30.24	8.08	1,083.02	39.24	5.55
ERCT	ERCOT All	1,324.35	18.65	15.11	1,118.86	20.15	5.68
FRCC	FRCC All	1,318.57	45.92	16.94	1,353.72	48.16	12.95
HIMS	HICC Miscellaneous	1,514.92	314.68	46.88	1,674.15	338.44	51.42
HIOA	HICC Oahu	1,811.98	109.47	23.62	1,855.10	120.11	20.79
MROE	MRO East	1,834.72	27.59	30.36	1,828.63	28.82	25.20
MROW	MRO West	1,821.84	28.00	30.71	2,158.79	45.57	35.22
NEWE	NPCC New England	927.68	86.49	17.01	1,314.53	77.47	16.02
NWPP	WECC Northwest	902.24	19.13	14.90	1,333.64	49.28	18.73

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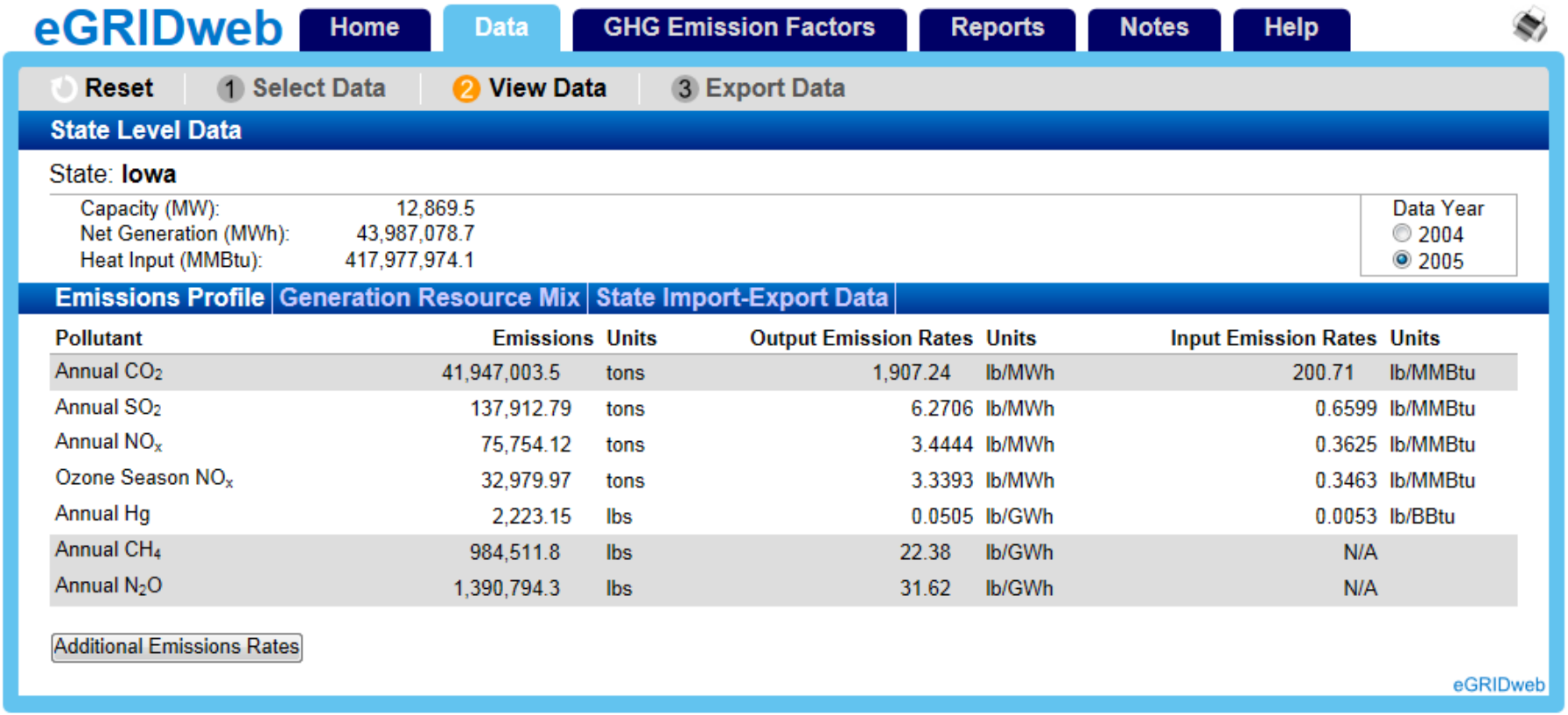

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Miscellaneous Sources

- Fertilizer use – emission factors based on N applied
- Solid waste – emission factors, life cycle options
  - Reuse/recycle vs. landfill vs. compost vs. flare vs. cogenerate
  - Landfill decay/gas generation rates based on state's climate
  - Animal waste - storage and treatment options, type of waste
- Cogeneration
  - Need fuel input, steam efficiency, steam and electric generation
- Lime/limestone use – based on chemistry, application
- Aviation – airport pairs, number of trips, assumed plane type (large, medium, small)
- Commuting – distances, MPG

Sample Carbon Footprint Calcs

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Documentation Requirements

- Build your inventory from direct records
  - Utility bills, bulk fuel purchases, landfill weights, etc.
  - Avoid multiple ‘unit conversions’ if possible
  - If interim spreadsheets are used, document and QC them
  - If metering is used, be sure to have sufficient coverage
    - Calibration can be important too
  - Establish data collection processes
    - i.e. tracking personal vehicle miles from expense reports, rental cars, air travel
    - Work with vendors to build reporting into their services
- If emission trading or regulatory, will need very good records; voluntary programs trending that way as well.

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Mandatory Reporting for EPA

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Mandatory Reporting Categories

- Electricity generation
- Adipic acid production
- Aluminum production
- Ammonia manufacturing
- Cement production
- HCFC–22 production
- HFC–23 destruction
- Lime manufacturing
- Nitric acid production
- Petrochemical production
- Petroleum refineries
- Phosphoric acid production
- Silicon carbide production
- Soda ash production
- Titanium dioxide production
- Municipal solid waste landfills that generate CH_4 in amounts equivalent to 25,000 metric tons CO_2e
- Ferroalloy Production
- Glass Production
- Hydrogen Production
- Iron and Steel Production
- Lead Production
- Pulp and Paper Manufacturing
- Zinc Production

The facility emits 25,000 metric tons CO_2e or more per year in combined emissions from all stationary fuel combustion sources.

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Mandatory Reporting Program

- Calendar year 2010 reports due Sept 30, 2011
- Reporting via EPA e-GGRT system
- Source definition, GHG Monitoring Plan

- Most facilities fall under Subpart C – General Stationary Fuel Combustion Facilities

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Calculations

- Fuel Combustion Emission Calculation:

$$CO_2 = 1 \times 10^{-3} * Fuel * HHV * EF$$

Where,

CO_2 = *metric tons* CO_2

Fuel = amount of fuel used (units)

HHV = Higher heating value (MMBtu/units)

EF = CO_2 *emission factor (kg/MMBtu)*

- Same approach with CH_4, N_2O factors

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EPA Emission Factors

TABLE C–1 TO SUBPART C OF PART 98

DEFAULT CO_2 EMISSION FACTORS AND HIGH HEAT VALUES FOR VARIOUS TYPES OF FUEL

Fuel type	**Default HHV**	**Default CO_2 E.F.**
Coal and coke	**mmBtu/short ton**	**kg CO_2/mmBtu**
Anthracite	25.09	103.54
Bituminous	24.93	93.40
Sub-bituminous	17.25	97.02
Lignite	14.21	96.36
Coke	24.80	102.04
Natural gas	**mmBtu/scf**	**kg CO2/mmBtu**
Pipeline (Weighted U.S. Average)	1.028×10^{-3}	53.02
Petroleum products	**mmBtu/gallon**	**kg CO2/mmBtu**
Distillate Fuel Oil No. 2	0.138	73.96
Residual Fuel Oil No. 6	0.150	75.10
Liquefied petroleum gases (LPG)	0.092	62.98

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CH_4 and N_2O Factors

Table C-2 to Subpart C - Default CH_4 and N_2O Emission Factors for Various Types of Fuel

Fuel Type	Default CH_4 Emission Factor (kg CH_4/mmBtu)	Default N_2O Emission Factor (kg N_2O/mmBtu)
Coal and Coke (All fuel types in Table C-1)	1.1E-02	1.6E-03
Natural Gas	1.0E-03	1.0E-04
Petroleum (All fuel types in Table C-1)	3.0E-03	6.0E-04
Municipal Solid Waste	3.2E-02	4.2E-03
Tires	3.2E-02	4.2E-03
Blast Furnace Gas	2.2E-05	1.0E-04
Coke Oven Gas	4.8E-04	1.0E-04
Biomass Fuels - Solid (All fuel types in Table C-1)	3.2E-02	4.2E-03
Biogas	3.2E-03	6.3E-04
Biomass Fuels – Liquid (All fuel types in Table C-1)	1.1E-03	1.1E-04

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EPA Reporting Tiers Based on Data

Tier	Heating Value Source	Emission Factor Source
Tier 1	HHV from Table	Default Factor
Tier 2a	HHV from Samples	Default Factor
Tier 2b	HHV from Samples	Default Factor
Tier 2c	Steam and heat rate	Default Factor
Tier 3	-	Mass Balance on C
Tier 4	-	CEM

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- EPA has provided spreadsheets for calculation, documentation

Subpart	Calculation Spreadsheets (click to download)
C - Combustion	Equation C-1, C-8 Calculation Spreadsheet.xls
C - Combustion	Equation C-1a, C-8a Calculation Spreadsheet.xls
C - Combustion	Equation C-1b, C-8b Calculation Spreadsheet.xls
C - Combustion	Equation C-2a, C-2b, C-9a Calculation Spreadsheet.xls
C - Combustion	Equation C-2c, C-9b Calculation Spreadsheet.xls
C - Combustion	Equation C-3, C-8 Calculation Spreadsheet.xls
C - Combustion	Equation C-4, C-8 Calculation Spreadsheet.xls
C - Combustion	Equation C-5, C-8 Calculation Spreadsheet.xls
C - Combustion	Equation C-10 Calculation Spreadsheet.xls
C - Combustion	Equation C-11 Calculation Spreadsheet.xls

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	A	B	C	D	E	F
1	**Subpart C - General Stationary Fuel Combustion - Tier 1 Calculation Methodology Using Equations C-1 and C-8**					
2	OPTIONAL SPREADSHEET FOR FACILITY RECORDKEEPING PURPOSES					
3	Version	e-GGRT RY2010.R.02				
4	Today's date	8/13/2011				
5	Use one spreadsheet for each fuel. Make additional copies as needed.					
6						
7	This spreadsheet is protected and contains locked cells to ensure that you do not inadvertently alter any of the included formulas and/or					
8	calculations. To remove this protection and alter this spreadsheet, right-click the "worksheet" tab near the bottom of the screen and select					
9	"Unprotect Sheet." When prompted for the password, type "GHG" and click "OK." Please note that making changes to an unprotected sheet					
10	could result in incorrect calculations and that you are responsible for the accuracy of the data you report to EPA. For additional help, visit the Microsoft Excel Support website (http://office.microsoft.com/en-us/excel-help).					
11						
12	**Equation C-1:**	$CO_2 = 1x10^{-3} * Fuel * HHV * EF$				
13						
14						
15						
16						
17	**Equation C-8:**	$CH_4 \text{ or } N_2O = 1x10^{-3} * Fuel * HHV * EF$				
18						
19						

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29			
30	**Fuel Input Data**		
31		**[Fuel]** = Mass or volume of fuel combusted per year, from company records as defined in §98.6 (express mass in short tons for solid fuel, volume in standard cubic feet for gaseous fuel, and volume in gallons for liquid fuel)	23,454.
32		**[HHV]** = Default High heat value of the fuel, from Table C-1 (mmBtu/mass or mmBtu/volume)	24.93
33			
34	**Constants**		
35		**[1 x 10^{-3}]** = Conversion Factor from kg to metric tons (constant)	0.001
36			
37	**Annual CO_2 Mass Emissions For the Specific Fuel Type (metric tons) from Equation C-1**		
38			
39		**[EF]** = Fuel-Specific Default CO_2 Emission Factor, from Table C-1 (kg CO_2/mmBtu)	93.4
40		**[CO_2]** = Annual CO_2 emissions from combustion of the specified fuel (metric tons)	**54611.7**
41			
42			Enter this value in e-GGRT

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44	**Annual CH_4 Mass Emissions For the Specific Fuel Type (metric tons) from Equation C-8**	
45		
46	**[EF]** = Fuel-Specific Default Emission Factor for CH_4, from Table C-2 (kg CH_4/mmBtu)	0.011
47	**[CH_4]** = Annual CH_4 emissions from combustion of the specified fuel (metric tons)	**6.43**
48		
49		Enter this value in e-GGRT
50		
51	**Annual N_2O Mass Emissions For the Specific Fuel Type (metric tons) from Equation C-8**	
52		
53	**[EF]** = Fuel-Specific Default Emission Factor for N_2O, from Table C-2 (kg N_2O/mmBtu)	0.0016
54	**[N_2O]** = Annual N_2O emissions from combustion of the specified fuel (metric tons)	**0.936**
55		
56		Enter this value in e-GGRT

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58	**Annual CH_4 Mass Emissions For the Specific Fuel Type Converted to Carbon Dioxide Equivalent (metric tons CO_2e)**
59	
60	**[GWP_{CH4}]** = Global Warming Potential for CH_4 — 21
61	**[CH_4]** = Annual CH_4 emissions from combustion of the specified fuel (metric tons CO_2e) — 135.0675988
62	
63	
64	
65	**INFORMATION ONLY: Annual N_2O Mass Emissions For the Specific Fuel Type Converted to Carbon Dioxide Equivalent (metric tons CO_2e)**
66	
67	**[GWP_{N2O}]** = Global Warming Potential for N_2O — 310
68	**[N_2O]** = Annual N_2O emissions from combustion of the specified fuel (metric tons CO_2e) — 290.0152771
69	

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Subpart C Overview

OVERVIEW OF SUBPART C REPORTING REQUIREMENTS

Subpart C requires affected facilities to report annual carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions from each stationary combustion unit. First, use this page to identify each stationary combustion reporting *configuration* (reporting options listed in §98.36) and then enter emissions information required by subpart C for each configuration.

For additional information about subpart C reporting, please use the e-GGRT Help link (s) provided.

EPA has finalized a rule that defers the deadline for reporting data elements used as inputs to emission equations for direct emitters. See 76 FR 53057 (published August 25, 2011). In accordance with the rule, e-GGRT is not currently collecting data used as inputs to emission equations.

Subpart C: View Validation

CONFIGURATION SUMMARY

Configuration Name or ID	Configuration Type	Status[1]		Delete
EU-6	Single Unit Using Tiers 1, 2, or 3	Complete	OPEN	✖
EU-7	Single Unit Using Tiers 1, 2, or 3	Complete	OPEN	✖
GP-UI-1	Aggregation of Units	Complete	OPEN	✖

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Unit Type	S (Stoker Boiler)
Maximum Rated Heat Input Capacity	206.3 (mmBtu/hr)

Edit this Configuration Information

CONFIGURATION-LEVEL EMISSIONS INFORMATION

Total Biogenic CO_2 Emissions (metric tons)	Total CO_2 Emissions from Sorbent Usage (metric tons)	Status[1]	
413.3	0.0	Complete	OPEN

FUEL-SPECIFIC EMISSIONS INFORMATION (for fuels combusted at this reporting configuration)

Fuel	Calculation Period	Methodology	Status[1]		Delete
Agricultural Byproducts	01/01/2010 - 12/31/2010	Tier 1 (Equation C-1)	Complete	OPEN	✖
Bituminous	01/01/2010 - 12/31/2010	Tier 2 (Equation C-2a)	Complete	OPEN	✖
Wood and Wood Residuals	01/01/2010 - 12/31/2010	Tier 1 (Equation C-1)	Complete	OPEN	✖

ADD a Fuel

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Fuel (Fuel Type)	Agricultural Byproducts (Biomass fuels - solid)
Reporting Period	01/01/2010 - 12/31/2010

EQUATION C-1 SUMMARY AND RESULT

$CO_2 = 1x10^{-3} \times Fuel \times HHV \times EF$

Hover over an element in the equation above to reveal a definition of that element.

Annual CO_2 emissions from combustion of the specified fuel (include both biogenic and non-biogenic emissions)	61.8 (metric tons) Use Equation C-1/C-8 spreadsheet to calculate

EQUATION C-8 SUMMARY AND RESULTS

CH_4 or $N_2O = 1x10^{-3} \times Fuel \times HHV \times EF$

Hover over an element in the equation above to reveal a definition of that element.

Annual CH_4 emissions from combustion of the specified fuel	0.02 (metric tons) Use Equation C-1/C-8 spreadsheet to calculate
Annual N_2O emissions from combustion of the specified fuel	0.002 (metric tons) Use Equation C-1/C-8 spreadsheet to calculate

CO_2 EQUIVALENT EMISSIONS

CO_2 equivalent value for Annual CH_4 emissions	0.4 (metric tons)

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CONFIGURATION-LEVEL EMISSIONS INFORMATION

Total CO_2 Emissions from Fossil Fuels (metric tons)	Total Biogenic CO_2 Emissions (metric tons)	Total CO_2 Emissions from Sorbent Usage (metric tons)	Status[1]	
32,925.2	0.0	0.0	Complete	OPEN

FUEL-SPECIFIC EMISSIONS INFORMATION (for fuels combusted at this reporting configuration)

	Fuel	Calculation Period	Methodology	Status[1]		Delete
	Natural Gas (Weighted U.S. Average)	01/01/2010 - 12/31/2010	Tier 1 (Equation C-1)	Complete	OPEN	

ADD a Fuel

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Scope 3 Product Chain Accounting

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Basic Scope 3 Activities

- Production of purchased materials
- Product use
- Outsourced activities
- Contractor owner vehicles
- Waste disposal
- Employee business travel
- Leased assets

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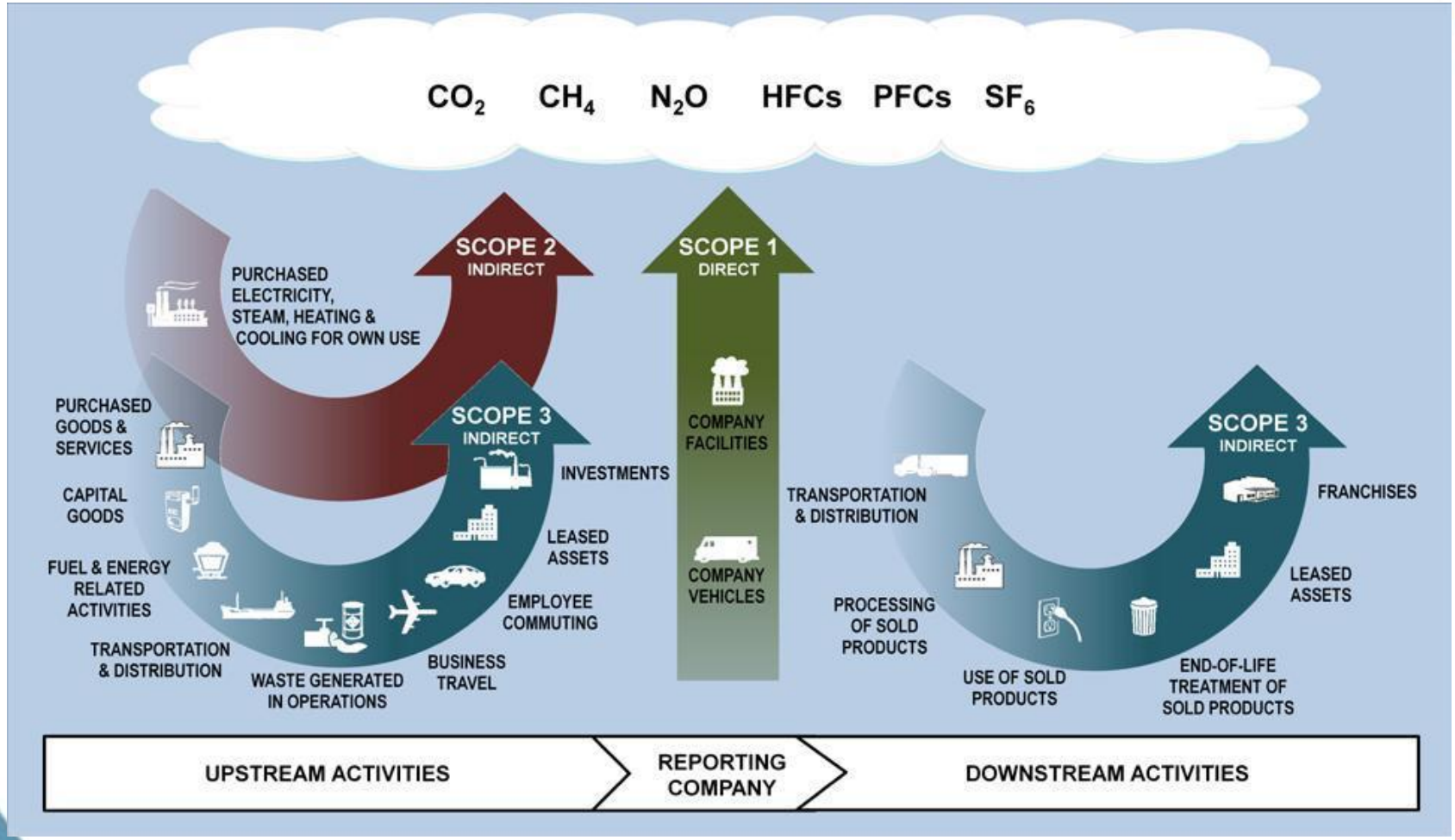
The Expansion of Scope 3



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Scope 3 – Upstream

- Extraction and production of purchased materials
- Transport of:
  - Purchased materials and goods
  - Purchased fuels
  - Employee business travel
  - Employee commuting
  - Sold products
  - Waste

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Scope 3 – Upstream

- Electricity that is not in Scope 2:
  - Transport of fuels for electricity production
    - Your own, and purchased, electricity
  - Purchased electricity re-sold to an end-user
  - Generation of electricity that is sold through a transmission and distribution system
- Leased assets that are not included in your organizational boundary

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Scope 3 – Upstream

- Waste disposal
  - From your operation
  - From production of purchased materials and fuels

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Scope 3 – Downstream

- Use of your products
- Waste disposal
  - From end-of-life disposal of your products

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Including Scope 3 Emissions?

- They are large (or believed to be large) relative to the company's scope 1 and scope 2 emissions
- They contribute to the company's GHG risk exposure
- They are deemed critical by key stakeholders (feedback from customers, suppliers, investors, or society)
- There are potential emissions reductions that could be undertaken or influenced by the company.

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Thank You

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